Biomass and net productivity for spruce plantation

Ma Chenghui (马承惠) Mu Liqiang (穆丽蔷)
Northeast Forestry University, Harbin 150040, P.R. China

Yao Zhongliang(姚忠良)
Shonghuajiang Forestry School, Heilongjiang, China

Liu Peng(刘鹏) Sun Jianfeng(孙剑峰)
Northeast Forestry University, Harbin 150040, P.R. China

Abstract The biomass of spruce (*Picea koraiensis*) plantation in the Suiling district of Heilongjiang Province was systematicly studied. Net productivities and their distribution biomass of the stem, bark, branch, leaf and root on the arborous layer of spruce plantation from 6 to 31 a were investigated and stem analyses using mean sample method. The regression equations for estimating the biomass of different organs of individual trees were set up. The result showed that the biomass of stand was 151 t/hm^{-2} and net productivity was 11~14 $t/(hm^2 \cdot a)$.

Key words: Spruce, *Picea koraiensis*, Plantation, Biomass, Net productivity

Site and method

The site is located in the Suiling District of Heilongjiang Province from N 47° 26' to N 48° 06', E 127° 37' to E 128° 28'. The average slope is 15°. The mean elevation is 349 m. The mean annual temperature is -0.4℃. The accumulated temperature of ≥10℃ is 1986℃. The amount of precipitation is from 600 to 800 mm. The frost-free season is about 130 d. The main soil is dark brown soil.

The 17 plots (0.04 hm^2) for different ages, different sites were measured. One sample tree was selected in every plot. The fallen stem analysis trees were divided with one meter or two meters. The weight of stems was measured. The discs were cut. The fresh weights of branches and leaves were measured. Because the roots of spruce is shallow. All roots were dug.

Result and analysis

Setting up regression equation of biomass for different organs

The independent variables were D and D^2 H. The weight of stems, parks and leaves, the weight above ground, root weight, the whole weight were selected as dependent variables. The models were fitted using the linear regression, logarithmic regression, exponent regression polynomial regression and power equation. The best regression equations of biomass for different organs were selected according to related coefficients (see Table 1).

Biomass of arborous layer for different ages

The total biomass of arborous layer was increasing with the age (see Table 2). There were some specials. It was related to density, thinning management and site factors.

At young age (<18) the proportion of leaves is the most. But after 18 years the proportion of stems is the most. Park and branch change a little. At the young age the proportion of roots is less than the leaves. The proportion of roots decreased with the age. But when age was about 30 a, the growth of roots increased again and their proportion was less than the stem. The order of proportion for different organs was stems >roots >leaves > branches >parks.

Net productivity did not increase with the age. In general at the age about 30 a, Net productivity was 11-14 $t/(hm^2 \cdot a)$. But the good site, for example 22 a, Net productivity reached 17.77 $t/(hm^2 \cdot a)$ (Table 3).

The proportion of net productivity of leaves decreased with the age. The proportion of net productivity of stems was not large. At the about 30 years, the order of productivity was stems > roots > branches> leaves > barks.

Conclusions

Through the analysis of biomass and net productivity for different ages, the biomass increased with the age. At the age of 31 a, the mean biomass at about

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age of 30a net productivity was 11-14 t/(hm^2•a).

The distribution proportion of biomass and net productivity for different ages was very different. When the age reached more than 30 a, the order of the biomass was stems > roots > leaves > branches > barks. The order of net productivity was stems > roots > branches > leaves > barks.

Table 1. The regression equations between biomass of different organs and D and D^2 H

Types	Regression equation	References A	b	c	Related Coefficient (P<0.01)
Roots biomass	$W_R=a+bD+cD^2$	1.9580	-1.3556	0.1834	0.9646
$W_R=a\text{-}bc^D$	$W_R=a\text{-}bc^D$	-0.9115	-0.6040	0.9642	0.9642
Stem biomass	$W_S=a+bD+cD^2$	2.9386	- 2.1784	0.3607	0.9884
	$W_S=a-bc^D$	1.2534	-2.7654	-2.0115	0.9924
	$W_S=a+b\ (D^2H)$	1.0120	1.6386×10^{-2}	/	0.9924
	$W_S=a[1-\mathrm{Exp}\ (bD^2)\ ]^c$	31.0552	1.004×10^{-3}	0.9882	0.9742
Bark biomass	$W_{Ba}=a+bD+cD^2$	0.5205	-0.3430	0.0563	0.9772
	$W_{Ba}=a-bc^D$	1.2478	-0.494	-0.3308	0.9794
	$W_{Ba}=a+b\ (D^2H)$	0.2195	2.5311×10^{-3}	/	0.9757
Branches biomass	$W_{Br}=a\ (D^2H)^b$	0.0693	0.6009	/	0.9421
	$W_{Br}=a\{1-\mathrm{Exp}[-b\,(D^2H)]^c$	6.1401	1.001×10^{-3}	0.6625	0.9391
	$W_{Br}=a-bc^D$	1.1667	-1.3001	1.1667	0.9335
Foliage biomass	$W_L=a+b\ (D^2H)$	0.8371	4.8801	/	0.9500
	$W_L=a-bc^D$	1.2977	0.1699	-0.3655	0.9537
Above ground	$W_A=a-bc^D$	1.2483	-3.9075	-3.5071	0.9966
biomass	$W_A=a+bD+cD^2$	5.2883	-2.3268	0.5775	0.9918
Total biomass	$W_T=a-bc^D$	1.2564	-4.7360	-4.0313	0.9979
	$W_T=a+bD+cD^2$	7.1914	-4.6716	0.7604	0.9939
	$W_T=a+b\ (D^2H)$	2.9624	3.3988×10^{-2}	/	0.9938

Table 2. The biomass of arborus layer for different ages (t /hm^2)

Age	Stem	Bark	Branches	Foliage	Root	Aboveground	Total
31	73.504	9.886	16.154	20.509	31.075	120.05	151.13
	48	7	11	13	21	79	100
30	38.924	7.590	8.067	18.202	16.620	72.778	89.397
	44	8	9	20	19	81	100
29	68.684	12.380	11.470	17.980	20.336	110.514	130.851
	52	9	9	14	16	84	100
25	19.851	2.891	5.482	5.931	6.812	34.155	41.037
	48	7	13	14	18	82	100
22	33.654	6.454	12.739	21.958	9.559	74.805	84.364
	40	8	15	26	11	89	100
18	2.079	0.756	1.426	3.716	1.361	7.978	9.339
	22	8	15	40	15	85	100
16	4.742	1.097	2.313	4.499	1.705	12.652	14.357
	33	8	16	31	12	88	100
13	0.361	0.147	0.794	2.704	0.633	4.007	4.640
	8	3	17	58	14	86	100
12	0.079	0.024	0.105	0.180	0.070	0.388	0.458
	17	5	23	40	15	85	100
11	0.697	0.205	0.9061	1.828	0.564	3.639	4.198
	17	5	22	44	12	88	100
10	0.914	0.498	0.821	1.562	0.583	3.796	4.376
	20	11	19	36	14	86	100
6	0.0133	0.0051	0.0064	0.0229	0.0092	0.0477	0.0569
	24	9	11	40	16	84	100

Where: The denominator is percentage

Table 3. The net productivity of arborus layer for different ages($t/hm^2 \cdot a$)

Age	Stem	Bark	Branches	Foliage	Roots	Aboveground	Total
31	7.0514	1.2132	1.4755	0.6825	2.8539	11.2625	14.1164
	56	8	10	5	20	8	100
31	5.8124	0.8012	2.3312	1.8290	4.3130	10.7737	15.0867
	39	5	14	12	29	71	100
31	6.7718	0.7136	0.9696	1.0989	1.5252	9.5536	15.0867
	61	6	9	10	14	86	100
30	3.0087	0.5867	0.6235	0.5332	1.0864	4.7584	5.8448
	51	10	11	9	19	81	100
29	7.7242	1.3923	1.2898	0.6219	2.0293	11.0282	13.0575
	59	10	10	5	16	84	100
25	2.9547	0.4304	0.8160	0.7042	0.9883	4.9055	5.8938
	50	7	14	12	17	83	100
22	8.7062	1.6697	3.2955	2.0872	2.0137	15.7589	17.7726
	49	9	19	12	11	89	100
18	0.4514	0.1640	0.3095	1.5932	0.4297	2.5186	2.9482
	15	6	10	54	15	85	100
13	0.0722	0.0294	0.1589	0.2803	0.0853	0.5409	0.6262
	12	4	25	45	14	86	100
10	0.2754	0.1503	0.2391	0.8616	0.2071	1.5351	1.7422
	16	9	14	49	12	88	100

Where: The denominator is percentage

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